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## (54) Low voltage contactor

(57) A low voltage contactor comprising a case which contains at least a first fixed contact and a second fixed contact which are suitable to be connected to an electric circuit, a movable conductive arm provided with a first contact piece and a second contact piece, and actuating means which supply the energy for moving the movable conductive arm. The actuating means comprise a rotary switching bar operatively connected to the movable conductive arm, and a command unit comprising a motor which drives into rotation said rotary switching bar and the movable conductive arm operatively connected therewith so as the first and the second contact pieces couple/uncouple electrically with the first and the second fixed contacts, respectively.

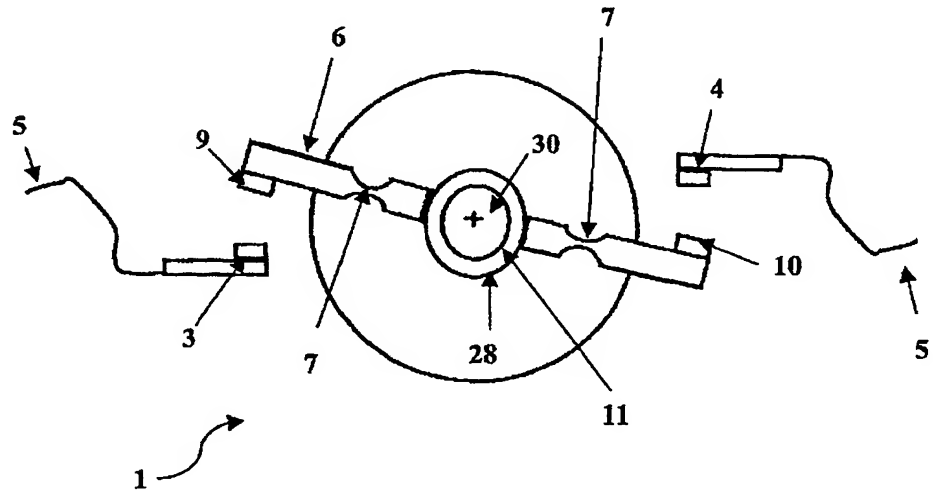


**Figure 3**

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## Description

**[0001]** The present invention relates to a low voltage contactor, i.e. a contactor for applications with operating voltages up to 1000 Volt.

**[0002]** As well-known in the art, low voltage contactors are electrical devices generally used for interrupting the nominal current flowing in the electric circuit or low voltage power distribution line in which they are inserted. At present, one of the most widely used constructive solution foresees the use of low voltage contactors of the electromagnetic type, i.e. contactors in which opening/closing operations are performed by means of an electromagnetic equipment. A schematic example of the structure and functioning of a known electromagnetic low voltage contactor is shown in figure 1. As illustrated, the low voltage contactor, indicated by the reference numeral 100, generally comprises, for each phase of the electric circuit in which it is inserted, a pair of fixed contacts 101 electrically connected to a phase conductor and a pair of corresponding movable contacts 102 which are mounted on a movable metal body 103; a ferromagnetic mass 106 is associated to the fixed contacts 101 and a coil 104 is wounded around it. Further, a spring 105 is mechanically interposed between the fixed contacts 101 and the movable contacts 102. During closing operations, an auxiliary current is injected in the coil 104 so as to generate a magnetic field; as a consequence, the metal body 103 is subjected to an attractive magnetic force which causes its translation and the coupling of the movable contacts 102 with the corresponding fixed contacts 101; in this situation, the current flows in the phase conductors of the circuit, and the spring 105 is compressed, thus storing a certain amount of elastic energy. If the contactor has to be open, the auxiliary current is no more injected into the coil 104, so as the magnetic field is null and the attractive magnetic force is no longer present. The metallic body 103 is therefore subjected only to the elastic reaction force of the pre-compressed spring 105 which, by releasing the energy previously stored, causes the translation of the body 103 and the separation of the movable contacts 102 from the fixed contacts 101; in this situation, the current flow in the circuit is interrupted.

**[0003]** At the present state of the art, known types of low voltage contactors, although they perform the operations required in a substantially satisfying way, still present some disadvantages and drawbacks. In particular, the presence of the electromagnetic equipment, and more specifically of the metallic elements 103 and 106, negatively affects the overall dimensions of the contactor and increases the manufacturing and assembling costs. Furthermore, the coil must be precisely sized and calibrated, thus entailing difficult and complicated operations in order to ensure satisfying performances and an adequate reliability. Finally, in order to perform closing operations in optimised times, the current injected into the coil must rapidly reach high values, thus requiring wires of large size, and then it must be continuously supplied so as to keep the contacts coupled. Clearly, these aspects may often cause a faster wear of the contactor, may influence its reliability and entail a non-optimised power consumption; further, the presence of the electromagnetic parts renders the contactor sensitive to possible external magnetic fields.

**[0004]** The aim of the present invention is to realize a low voltage contactor which allows to overcome the drawbacks and disadvantages of the known art, and in particular which has a simplified structure in comparison with known contactors and ensures, at the same time, optimised performances.

**[0005]** Within the scope of this aim, an object of the present invention is to realize a low voltage contactor which allows to execute opening/closing operations in an easier and more controlled way with respect to known contactors, and whose reliability is improved.

**[0006]** Another object of the present invention is to realize a low voltage contactor whose number of components, as well as its overall dimensions, are remarkably reduced.

**[0007]** A further object of the present invention is to realize a low voltage contactor, which allows to reduce the manufacturing and assembling costs.

**[0008]** This aim, these objects and others which will become apparent hereinafter are achieved by a low voltage contactor comprising a case which contains at least a first fixed contact and a second fixed contact which are suitable to be connected to an electric circuit, a movable conductive arm provided with a first contact piece and a second contact piece, and actuating means which supply the energy for moving said movable conductive arm. The low voltage contactor according to the invention, is characterized in that said actuating means comprise:

- a rotary switching bar operatively connected to said movable conductive arm; and
- a command unit comprising a motor which drives into rotation said rotary switching bar and the movable conductive arm operatively connected therewith so as said first and second contact pieces couple/uncouple electrically with said first and second fixed contacts, respectively.

**[0009]** Further characteristics and advantages of the invention will become apparent from the description of a preferred but not exclusive embodiment of a low voltage contactor according to the invention, illustrated only by way of non-limitative example in the accompanying drawings, wherein:

figure 1 is a schematic representation of a low voltage contactor of the known type;
figure 2 illustrates a block diagram of the low voltage contactor according to the invention;
figure 3 is a schematic frontal view of the low voltage

contactor according to a preferred embodiment of the invention;

figure 4 is a schematic plan view of a three-phase low voltage contactor according to the invention;

figure 5 is an exploded view of a piezoelectric motor used in the low voltage contactor according to the invention.

**[0010]** With reference to figures 2-5, the low voltage contactor 1 according to the invention comprises a case 2 which contains at least a first fixed contact 3 and a second fixed contact 4 which are suitable to be connected to a conductor of an electric circuit, schematically indicated in figure 3 by the reference numeral 5; inside the case 2, there is a movable arm 6 made of conductive material which is provided with a first contact piece 9 and a second contact piece 10, and actuating means 40 which supply the energy for moving the movable conductive arm 6. Advantageously, as indicated in figure 3, the actuating means 40 comprise a rotary switching bar 11, operatively connected to the movable conductive arm 6, and a command unit, indicated in figure 2 by the reference numeral 12, which comprises a rotating motor 13 and control electronic means 14 which are suitable for supplying electric command signals to the motor 13 itself.

**[0011]** As shown in figure 3, according to a preferred embodiment, the movable conductive arm 6 is mounted, and in particular directly fulcrumed, on the rotary switching bar 11 transversal to the rotation axis 30 of the bar 11 itself, with the first contact piece 9 and the second contact piece 10 which are positioned at the ends and on opposite sides of the movable conductive arm 6; in turn, the first fixed contact 3 and the second fixed contact 4 are positioned substantially symmetric to each other with respect to said rotation axis 30. Alternatively, the movable arm 6 may be connected to the bar 11 with an insulating element 28 interposed therebetween.

**[0012]** Further, according to a particularly preferred embodiment, the body of the movable contact arm 6 can be advantageously realized with at least two substantially rigid portions interconnected by means of a substantially flexible element 7, such as a flexible pivot obtainable by reducing the thickness of a portion of the arm 6 with respect to the surrounding parts; in this way, the movable conductive arm 6 is provided with a structural elasticity so as to compensate ageing and uneven wear of the contact pieces 9-10, 3-4, to guarantee adequate electric contact between them, and definitely to increase the useful life of the contactor.

**[0013]** Alternatively, the body of the arm 6 can be realized in a single substantially uniform body, or in two independent parts, each carrying a corresponding contact piece.

**[0014]** Advantageously, in the low voltage contactor according to the invention, the motor 13 is a rotating self-braking motor, i.e. a rotating motor in which braking during operation is obtained thanks to the intrinsic structure of the motor itself, without using additional braking devices; in particular, the rotating motor 13 used in the contactor 1 is a piezoelectric motor, i.e. a motor which comprises piezoelectric elements and whose operations are obtained by their electric excitement. More specifically, according to a particularly preferred embodiment, the piezoelectric motor is an ultrasonic piezoelectric motor, i. e. a motor in which the exciting signals are in the ultrasonic frequency range.

**[0015]** However, other types of rotating motors might be used, provided that they are suitable for the application.

**[0016]** One example of an ultrasonic piezoelectric motor suitable for being used in the low voltage contactor 1 according to the invention is shown in figure 5. As illustrated in this figure, the piezoelectric motor 13 comprises a stator unit and a rotor unit; the rotor unit comprises a metallic disc 15 which is structurally integral with the rotary switching bar 11; in this way, the rotary switching bar 11 constitutes the shaft of the motor 13 itself, according to a solution constructively simple and functionally effective. Alternatively, it would be possible to use as a rotary switching bar, an additional bar connected to the shaft of the motor 13. Further, a bearing 26 is associated to the rotary bar 11 in order to allow its rotation.

**[0017]** In turn, the stator unit comprises a flange 16 to which the bearing 26 is connected, and an annular elastic disc 17 which is also connected to the flange 16, and has a base plate 18 and a teeth-shaped ring 19 which protrudes transversally, in particular in a perpendicular direction, from the base plate 18; according to the applications and/or specific needs, the teeth-shaped ring 19 can be positioned at the external edge of the base plate 18, as indicated in figure 5, or along an internal circumference. Further, the stator unit comprises at least one layer of piezoelectric material 20, for example of the PZT type, which is fixed on the elastic disc 17; in particular, the layer of piezoelectric material 20 comprises a plurality of sectors 27 which are electrically excited by the command signals supplied by the control electronic means 14, for the purpose and in the way which will be described hereinafter.

**[0018]** The motor 13 further comprises friction means 21, for example constituted by a layer of rubber, which are positioned interposed between the metallic disc 15 and the teeth-shaped ring 19, and retaining means 22; for example, the retaining means 22 can be constituted by a metallic elastic body 23 which is positioned on a face of the metallic disc 15 opposite to the annular elastic disc 17, and a nut 24 which is screwed to a threaded end of the bar 11 and allows keeping the various elements of the rotor packed on the stator.

**[0019]** Damping means 25, constituted for example by a ring-shaped layer of rubber, are interposed between the retaining means 22 and the face of the metallic disc 15 opposite to the annular elastic disc 17, so as to dampen undesired vibrations of the motor.

**[0020]** During operations, for example when the contactor 1 has to be closed, the piezoelectric sectors 27 are excited by predefined excitation signals supplied by the control electronic means 14; in particular, adjacent pairs of piezoelectric sectors 27 are alternatively polarised, i.e. two adjacent sectors are both polarised in a direction perpendicular to the sectors themselves but in opposite directions, and fed with ultrasonic electric signals, i.e. voltage signals, which are, for instance, about 90°-phase shifted with respect to each other. As a consequence, the piezoelectric sectors 27 vibrate with a 90° phase-shift and the vibrations are transmitted to the annular elastic disc 17; in turn, the annular elastic disc 17 vibrates too and, thanks to the teeth of the ring 19, the small vibrations produced by the piezoelectric sectors are conveniently amplified. The composition of the two 90°-shifted vibrations brings to the generation of travelling waves along the ring 19; by means of the friction means 21, the movement is transmitted to the metallic disc 15 and thus, the rotor is dragged into rotation thanks to the friction action. In this manner, the rotary switching bar 11 is driven into rotation together with the movable conductive arm 6 operatively connected therewith, so as the first contact piece 9 and the second contact piece 10 couple electrically with the corresponding first fixed contact 3 and the second fixed contact 4, respectively. In this position, coupling between the contacts is ensured by the holding torque of the motor, thus avoiding the need of additional brakes; further, the power consumption required by the motor, is reduced with respect to conventional contactors, since feeding of the motor can be switched off in this position.

**[0021]** Starting from the closed position, in order to open the contactor, it is sufficient to invert of 180° the phase of one of the two electric signals supplied to the piezoelectric sectors 27 which have the same polarisation; in this way, the rotor rotates in the opposite direction and determines uncoupling of the contact pieces 9, 10 from the fixed contacts 3, 4.

**[0022]** The solution above described can be easily implemented for any kind of multi-phase low voltage contactors. A possible embodiment of a three-phase contactor 1 is schematically shown in figure 4 in which the neutral phase is not shown. In this case, inside the case (not shown) there are provided for each phase of the electric circuit 5 to which the contactor is connected, at least a first fixed contact 3 and a second fixed contact 4 which are suitable to be connected to a corresponding phase conductor of the circuit; further, for each phase, there is a movable conductive arm 6 provided with a first contact piece 9 and a second contact piece 10. The three arms 6 are connected to a unique rotary switching bar 11, transversally to its rotation axis 30, and the bar 11 is driven into rotation, together with the three arms 6, by a single motor 13, as previously described. In this case, coupling/uncoupling of the contact pieces 9, 10 with the corresponding fixed contacts 3, 4 can be realized synchronously among the various phases.

**[0023]** In practice, it has been found that the low voltage contactor 1 fully achieves the intended aim and objects, giving several advantages with respect to the known art.

**[0024]** In fact, in addition to the advantages previously mentioned, the use of actuating means as conceived in the contactor according to the invention, allows to simplify the structure of the whole contactor, and in particular to eliminate the electromagnetic equipment, thus realizing a contactor which is smaller and lighter, which has a reduced number of components and is substantially exempt from the effects of magnetic fields. Moreover, the absence of the electromagnetic equipment allows to reduce the manufacturing and assembling costs and the relative calibration operations, as well as to improve the reliability of the contactor.

**[0025]** The use of a rotating motor, and in particular of a self-braking ultrasonic piezoelectric motor, allows to realize a rotating contactor whose operations are executed in an easier and more controllable way, with negligible levels of electric power consumption required for moving the movable equipment and, above all, for keeping the contactor in the closed position. Further, the ultrasonic piezoelectric motor allows to have high torque levels at low speed and relatively reduced response times, and to perform substantially noise-free operations.

**[0026]** The low voltage contactor, according to the present invention, thus conceived is susceptible of numerous modifications and variations, all of which are within the scope of the inventive concept; for example it is possible to include in the command unit 12 an auxiliary power feeding element, such as a capacitor, which may be used for exciting the piezoelectric sectors if the reference voltage signal fed by the main circuit decreases under a predetermined threshold. All the details may also be replaced with other technically equivalent elements. In practice, the materials employed, so long as they are compatible with the specific use, as well as the dimensions, may be any according to the requirements and to the state of the art.

## Claims

1. A low voltage contactor (1) comprising a case (2) which contains at least a first fixed contact (3) and a second fixed contact (4) which are suitable to be connected to an electric circuit (5), a movable conductive arm (6) provided with a first contact piece (9) and a second contact piece (10), and actuating means (40) which supply the energy for moving said movable conductive arm (6), **characterized in that** said actuating means (40) comprise:

   - a rotary switching bar (11) operatively connected to said movable conductive arm (6); and
   - a command unit (12) comprising a motor (13)

which drives into rotation said rotary switching bar (11) and the movable conductive arm (6) operatively connected therewith so as said first and second contact pieces (9, 10) couple/uncouple electrically with said first and second fixed contacts (3, 4), respectively.

2. A low voltage contactor (1) according to claim 1, **characterized in that** said movable conductive arm (6) is mounted to the rotary switching bar (11) transversal to the rotation axis (30) thereof, with said first and second contact pieces (9, 10) positioned at the ends and on opposite sides of the movable conductive arm (6) itself, and **in that** said first and second fixed contacts (3, 4) are positioned substantially symmetric to each other with respect to said rotation axis.

3. A low voltage contactor (1) according to claim 1 **characterized in that** said command unit (2) comprise control electronic means (14) suitable for supplying electric command signals to said motor (13).

4. A low voltage contactor (1) according to claim 1, **characterized in that** said motor (13) is a rotating self-braking motor.

5. A low voltage contactor (1) according to claim 4, **characterized in that** said motor (13) is a piezoelectric motor.

6. A low voltage contactor (1) according to claim 5, **characterized in that** said motor (13) is an ultrasonic piezoelectric motor.

7. A low voltage contactor (1) according to claim 5 or 6, **characterized in that** said piezoelectric motor (13) comprises a stator unit and a rotor unit, said rotor unit comprising a metallic disc (15) which is structurally integral with said rotary switching bar (11).

8. A low voltage contactor (1) according to claim 7, **characterized in that** said stator unit comprises a flange (16), an annular elastic disc (17) which is operatively connected to said flange (16), said annular elastic disc (17) having a base plate (18) and a teeth-shaped ring (19) which protrudes transversally from the base plate (18), and at least one layer of piezoelectric material (20) which is connected to the annular elastic disc (17), said at least one layer of piezoelectric material (20) comprising a plurality of sectors (27) which are electrically excited by said command signals supplied by the control electronic means (14).

9. A low voltage contactor (1) according to one or more of claims 6-8 **characterized in that** said piezoelectric motor (13) comprises friction means (21) which are positioned interposed between the metallic disc (15) of the rotor unit and the teeth-shaped ring (19), retaining means (22) which are positioned at a face of the metallic disc (15) opposite to the annular elastic disc (17), and damping means (25) which are interposed between said retaining means (22) and said face of the metallic disc (15) opposite to the annular elastic disc (17).

10. A low voltage contactor (1) according to one or more of the preceding claims **characterized in that** said movable contact arm (6) comprises at least two substantially rigid portions which are interconnected by means of a substantially flexible element.

11. A multi-phase low voltage contactor (1) suitable to be connected to an electric circuit (5), comprising a case (2) which contains, for each phase of the electric circuit, at least a first fixed contact (3) and a second fixed contact (4) which are suitable to be connected to a corresponding phase conductor of the electric circuit (5), a movable conductive arm (6) provided with a first contact piece (9) and a second contact piece (10), and actuating means (40) which supply the energy for moving the movable conductive arm (6) of each phase, **characterized in that** said actuating means (40) comprise:

- a single rotary switching bar (11) operatively connected to each movable conductive arm (6); and
- a command unit (12) comprising a single motor (13) which drives into rotation said rotary switching bar (11) and the movable conductive arms (6) operatively connected therewith, so as the first and second contact pieces (9, 10) of each phase couple/uncouple electrically with the corresponding first and second fixed contacts (3, 4), respectively.

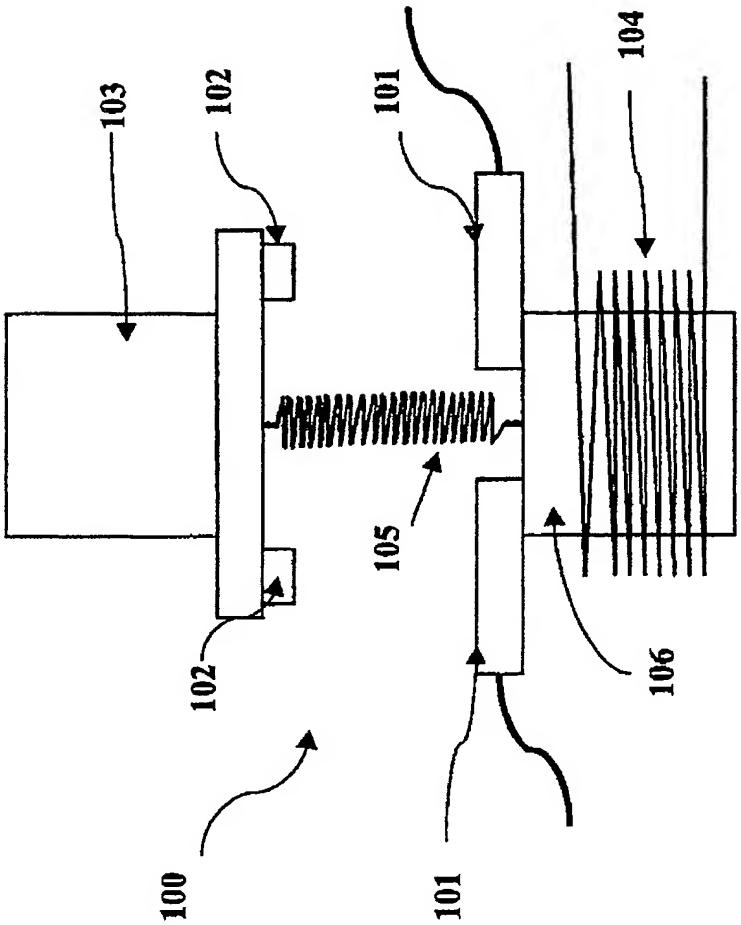


Figure 1

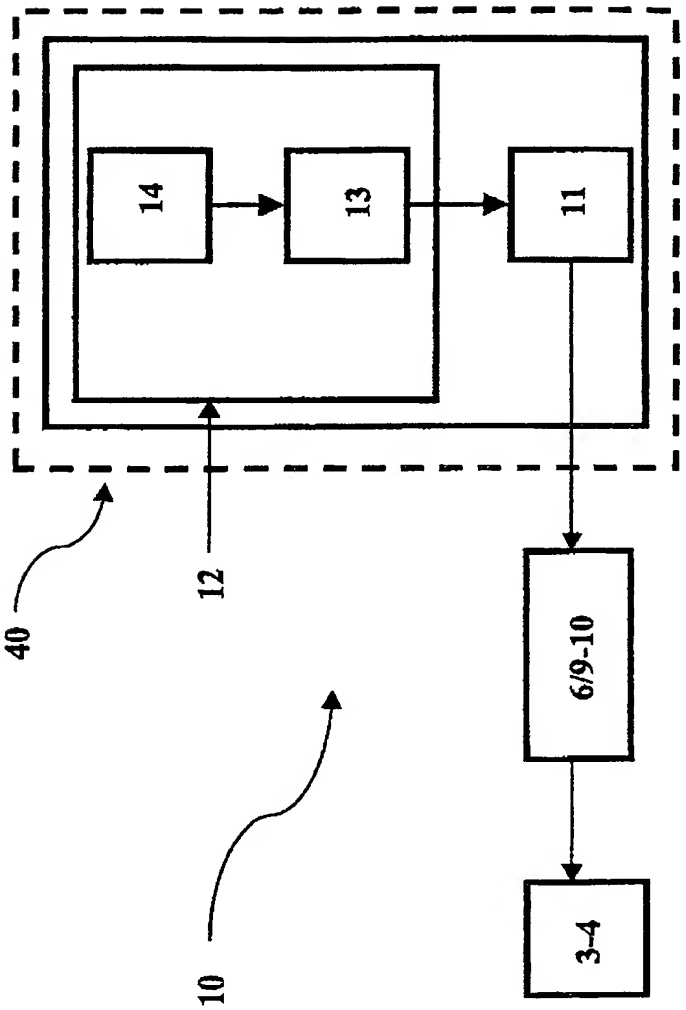


Figure 2

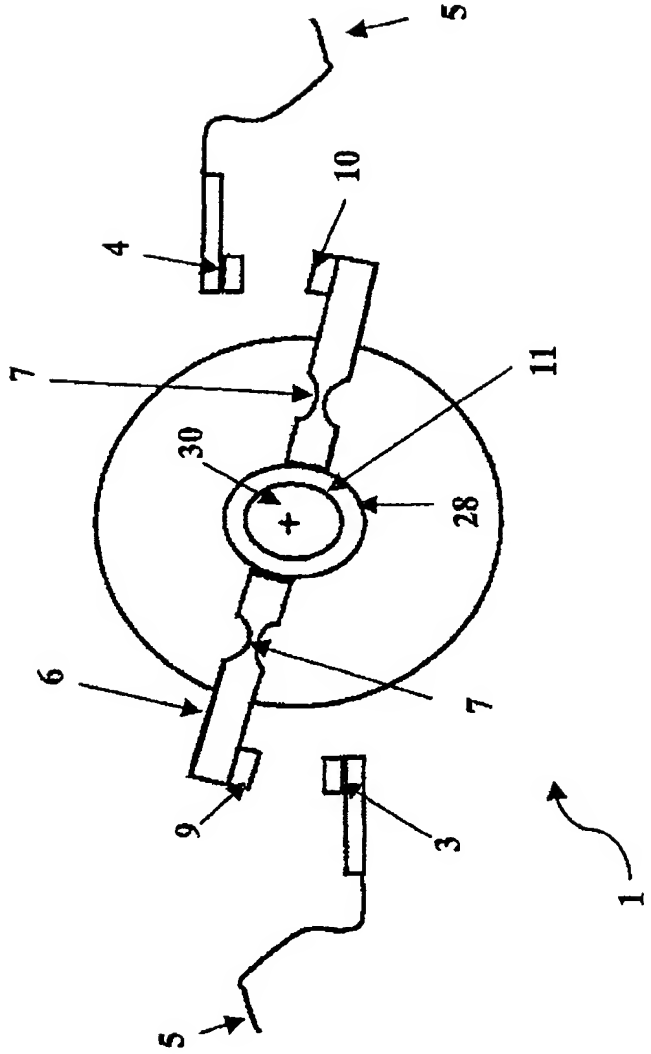


Figure 3

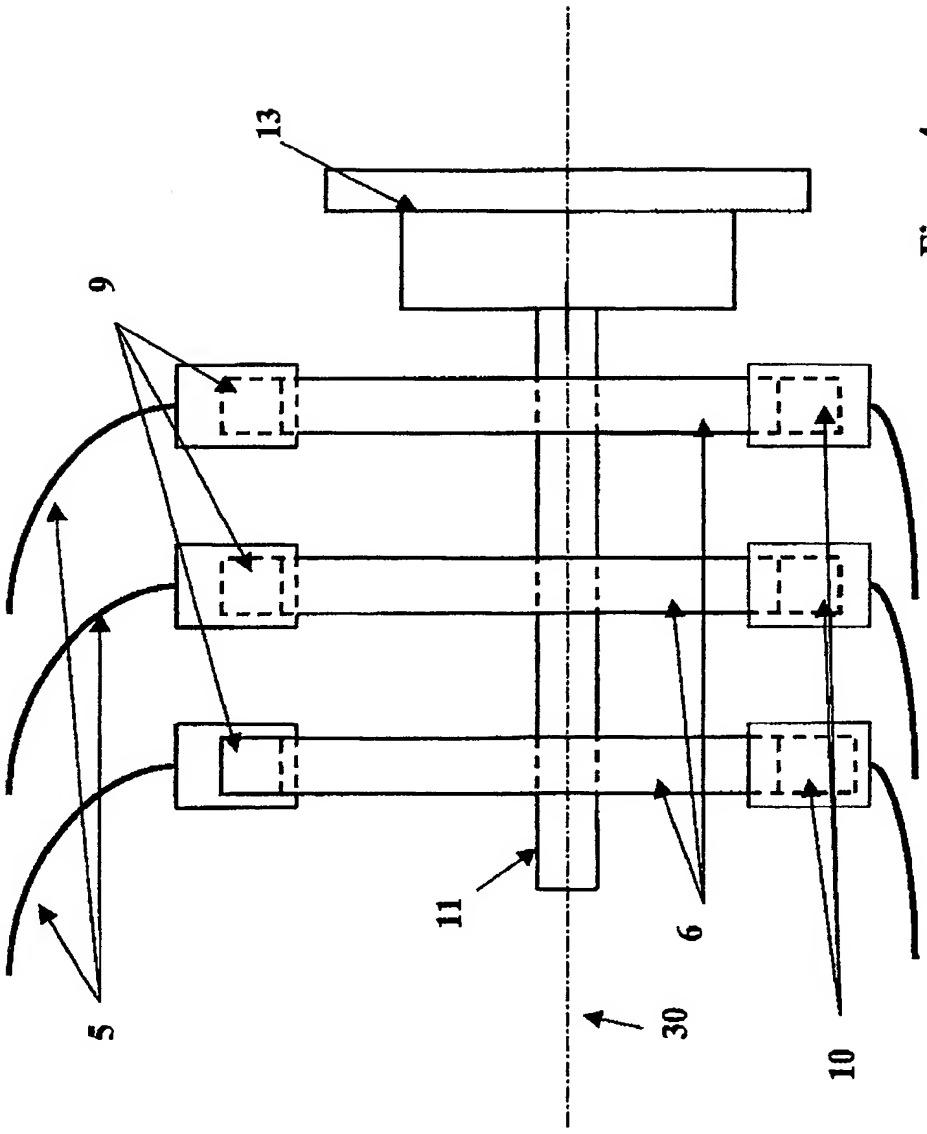


Figure 4

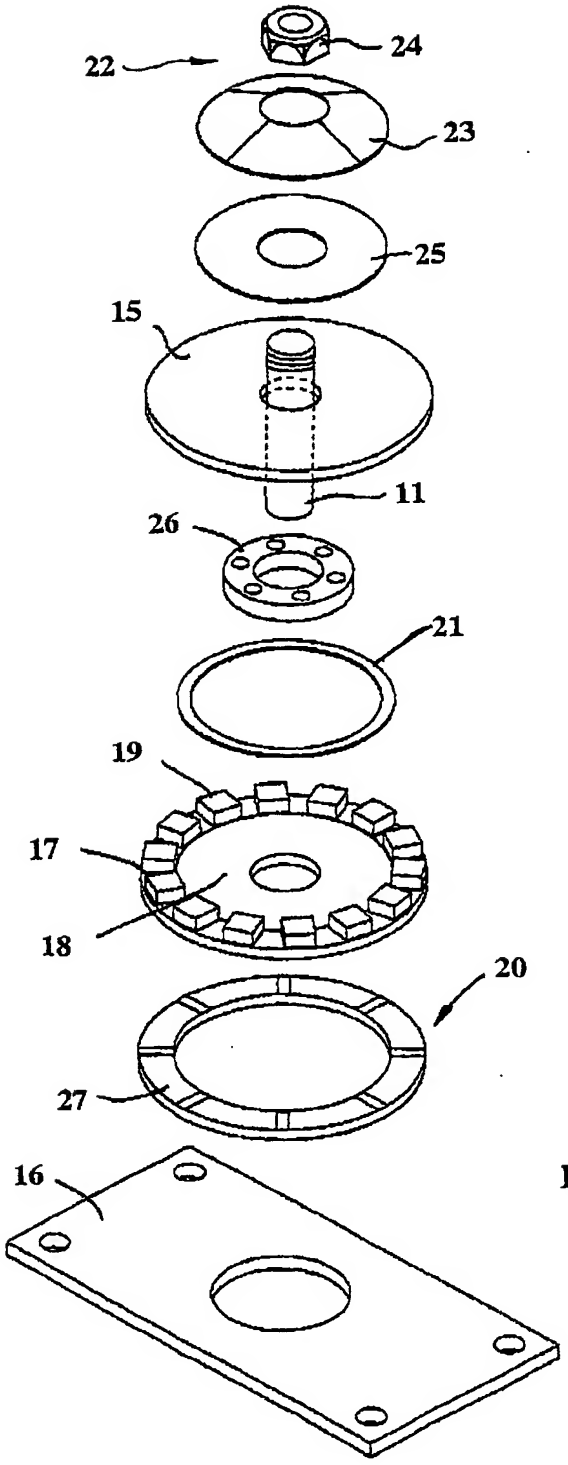


Figure 5

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# EUROPEAN SEARCH REPORT

Application Number
EP 01 20 2799

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int.Cl.7) |
|---|---|---|---|
| Y | EP 0 612 092 A (MERLIN GERIN) 24 August 1994 (1994-08-24) * column 4, line 4 - line 44 * | 1-11 | H01H57/00 |
| Y | PATENT ABSTRACTS OF JAPAN vol. 1999, no. 05, 31 May 1999 (1999-05-31) & JP 11 045649 A (FUJITSU TAKAMIZAWA COMPONENT KK), 16 February 1999 (1999-02-16) * abstract * | 1-11 | |
| A | US 5 170 088 A (NAITO KOICHI ET AL) 8 December 1992 (1992-12-08) * abstract * | 3-9 | |
| | | | TECHNICAL FIELDS SEARCHED (Int.Cl.7) |
| | | | H01H |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
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| THE HAGUE | 9 January 2002 | Libberecht, L |

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| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| EP 0612092 A | 24-08-1994 | FR 2701595 A1 | 19-08-1994 |
| | | DE 69412151 D1 | 10-09-1998 |
| | | DE 69412151 T2 | 11-02-1999 |
| | | EP 0612092 A1 | 24-08-1994 |
| | | ES 2120590 T3 | 01-11-1998 |
| JP 11045649 A | 16-02-1999 | NONE | |
| US 5170088 A | 08-12-1992 | NONE | |

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